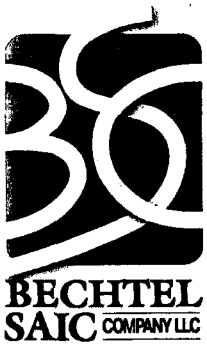

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June 2005

Aging Cask Design Development Plan

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Office of Civilian Radioactive Waste Management
Office of Repository Development
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BSC ENGINEERING STUDY

170-PLN-HA00-00300-000-000

Revision 000

June 2005

Aging Cask Design Development Plan

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ACRONYMS

BSC	Bechtel SAIC Company, LLC
DOE	U.S. Department of Energy
DDP	design development plan
HLW	high-level radioactive waste
ITS	important to safety
ITWI	important to waste isolation
LA	License Application
NRC	U.S. Nuclear Regulatory Commission
NSDB	nuclear safety design basis
SSCs	structure, system, and components
WP	waste package

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1. PURPOSE

This design development plan (DDP) identifies major milestones for advancing the design of metal aging casks containing bare fuel, metal overpacks with dual purpose canisters (DPCs) or Department of Energy (DOE) canisters, and concrete overpacks with DPCs or DOE canisters. The DDP identifies means of demonstrating that the casks and overpack systems will meet their credited safety functions at the repository. An "overpack system" is any combination of canister and overpack discussed in this plan.

Spent nuclear fuel (SNF) and high-level radioactive waste (HLW) arriving at the repository that is not yet ready for loading into waste packages is managed by placing it in the aging system. Aging is needed to allow some commercial SNF (CSNF) to cool to meet the thermal limits for emplacement. DOE SNF and DOE HLW are aged to assist in thermal management of emplacement drift loading. This DDP identifies the means of demonstrating that:

- Existing storage casks and overpack systems licensed in accordance with 10 CFR 72 [DIRS 173336] can be relied upon to perform the important to safety (ITS) functions identified in *Nuclear Safety Design Bases for License Application* (BSC 2005 [DIRS 171512]).

- Site-specific aging cask and overpack systems that will be licensed to 10 CFR 63 [DIRS 173273] can be relied upon to perform ITS functions identified in the *Nuclear Safety Design Bases for License Application* (BSC 2005 [DIRS 171512]).

A glossary of terms, for items such as "aging cask," "overpack", and "dual-purpose canister," is found in Appendix A. References and source documents used in this plan are listed in Section 11.

2. SCOPE AND OBJECTIVE

The scope and objective of this plan are to present a path forward for engineering, licensing, procurement, and placement into service of aging casks at the Yucca Mountain repository site.

2.1 Applicability

This plan applies to:

Commercially Available Cask and Overpack Systems

1. An existing 10 CFR 72 metal storage cask modified, if required, to allow aging of uncanisterized commercial spent nuclear fuel (CSNF) (Figure 4-1).

2. An existing 10 CFR 72 metal overpack with DPC modified, if required, to allow aging of canisterized CSNF (see Figure 4-2).

3. An existing 10 CFR 72 concrete overpack with DPC modified, if required, to allow aging of canisterized CSNF (Figure 4-3).

4. An existing 10 CFR 72 horizontal concrete storage module with a horizontally stored DPC modified, if required, to allow aging of canisterized CSNF (Figure 4-4).

Site Specific Cask and Overpack Systems

5. A newly designed metal cask for aging uncanistered CSNF (similar to Figure 4-1).

6. A newly designed metal aging overpack with a canister for aging DOE spent nuclear fuel (SNF) or high level waste (similar to Figure 4-2).

7. A newly designed concrete aging overpack with a canister for aging DOE SNF or high-level waste (similar to Figure 4-3).

2.2 Scope

This DDP describes the path forward for DOE to:

1. Obtain information from storage cask vendors who have licensed systems per 10 CFR 72 [DIRS 173336] to verify that these systems can be licensed to the requirements of 10 CFR 63 [DIRS 173273].

2. Provide the design development plan for site-specific aging casks and overpack systems that will be licensed to the requirements of 10 CFR 63 [DIRS 173273].

3. Provide the path forward to demonstrate satisfaction of the requirements listed in the nuclear safety design basis (NSDB) report (BSC 2005 [DIRS 171512]) for those casks and overpack systems listed in Section 2.1.

This plan also identifies gaps, if any, that exist between current industry codes and standards and current industry practices compared to the planned standards and practices at Yucca Mountain. The gap analysis, presented in Section 5, concludes whether or not an SSC is considered standard or nonstandard. The scope of the gap analysis in Section 5.0 identifies whether SSCs are readily available or not, and identifies if SSCs are currently utilized in the nuclear industry. This plan discusses how the project can "bridge-the-gap" between what has been accomplished already with currently available commercial casks, and what the repository needs to do for placing aging casks in service at Yucca Mountain.

The project has a research and development program to resolve safety questions for those SSCs that have been identified as being safety related and that need additional work to resolve the safety questions. The requirements for the program are described in the *Yucca Mountain Review Plan, Final Report* (NRC 2003 [DIRS 163274], p. 2.3-1). Since the aging casks are similar to existing systems and the gaps in information are known, the cask is not currently a candidate for inclusion in the formal research and development program required by the *Yucca Mountain Review Plan, Final Report* (NRC 2003 [DIRS 163274], Section 2.3). However, this does not preclude inclusion of aging cask development work in the Yucca Mountain research and development program in the future if, for any reason, the U.S. Nuclear Regulatory Commission (NRC) requires substantial new information.

2.3 Objectives

The primary objectives of this design development plan and the proposed path forward are:

- Demonstrate that commercial storage casks and overpack systems currently licensed under 10 CFR 72 [DIRS 173336] can, with minimal modifications, be made to comply with 10 CFR 63 [DIRS 173273] requirements and can be relied upon to meet ITS function as DOE aging casks.

- Demonstrate, through evaluation of currently licensed commercial casks and overpack systems at Independent Spent Fuel Storage Installations, that the existing technology and present industry practices are adequate to satisfy the repository aging functions under the repository design operating conditions for site specific casks and overpack systems.

- Demonstrate that site-specific aging casks and overpack systems licensed under 10 CFR 63 [DIRS 173273] can be relied upon to meet their ITS function.

3. QUALITY ASSURANCE AND COMPUTER SOFTWARE

This plan is subject to project requirements that require that quality assurance and computer software issues be addressed during execution of the work. The following sections summarize the quality assurance determination and software requirements.

3.1 Quality Assurance

This document was prepared in accordance with LP-ENG-014-BSC, *Engineering Studies* [DIRS 168862]. The results of this document are only to be used as the basis for selection of applicable codes and standards and are not to be used directly to generate quality-affecting products. Therefore, this engineering study is not subject to requirements of the *Quality Assurance Requirements and Description* document (DOE 2004 [DIRS 171539]).

The scope of this DDP includes the presentation of a plan for components that are credited in the repository safety case analysis. Design and development of these components will be accomplished by the implementation of planning, analysis, and possibly testing that will be accomplished in accordance with the *Quality Assurance Requirements and Description* (DOE 2004 [DIRS 171539]) document.

3.2 Computer Software

The only computer software used in this study (Microsoft Word) is classified as exempt from procedure LP-SI.11Q-BSC, *Software Management* [DIRS 171923]. All software used to prepare this analysis is listed under Section 2.1 Software Not Subject To This Procedure, of LP-SI.11Q-BSC, *Software Management* [DIRS 171923].

4. FUNCTIONAL DESCRIPTION

The function of the aging cask and overpack system is to provide heat transfer path, criticality control, radioactive shielding, and environmental protection for SNF and radioactive shielding and environmental protection for HLW.

This DDP applies to aging casks and overpacks that will be loaded in a vertical orientation at the repository site as well as horizontal aging modules loaded at the repository site. Bare CSNF will arrive in shipping casks from various CSNF producers. To facilitate return of the shipping cask to the transportation system, bare CSNF is transferred to one of the following:

1) A waste package for subsequent underground emplacement, or
2) An aging cask that will be placed on one of the aging pads by a cask transporter.

Canisterized fuel will arrive in shipping casks from various SNF producers. Non-disposable DPC that are received containing CSNF would be taken to the Dry Transfer Facility where it would be opened and the SNF transferred to a waste package. The DPC can also be transferred to an overpack that is taken to the aging pad by a cask transporter. If the canister contains DOE SNF or HLW, it is transferred directly to a waste package, or to an overpack facilitating the return of its shipping cask to the transportation system.

This DDP also applies to metal aging casks that will hold bare fuel (see Figure 4-1), and to metal or concrete overpacks with commercial DPCs or DOE canisters. A function of the metal aging cask and metal or concrete overpacks, is to provide a radiological protection and environmental protection to the SNF during the aging process. The canisters will be placed into a concrete overpack (see Figure 4-2), metal overpack (see Figure 4-3), or a horizontal aging module (see Figure 4-4) to facilitate the return of the canister's transportation cask to the national transportation system.

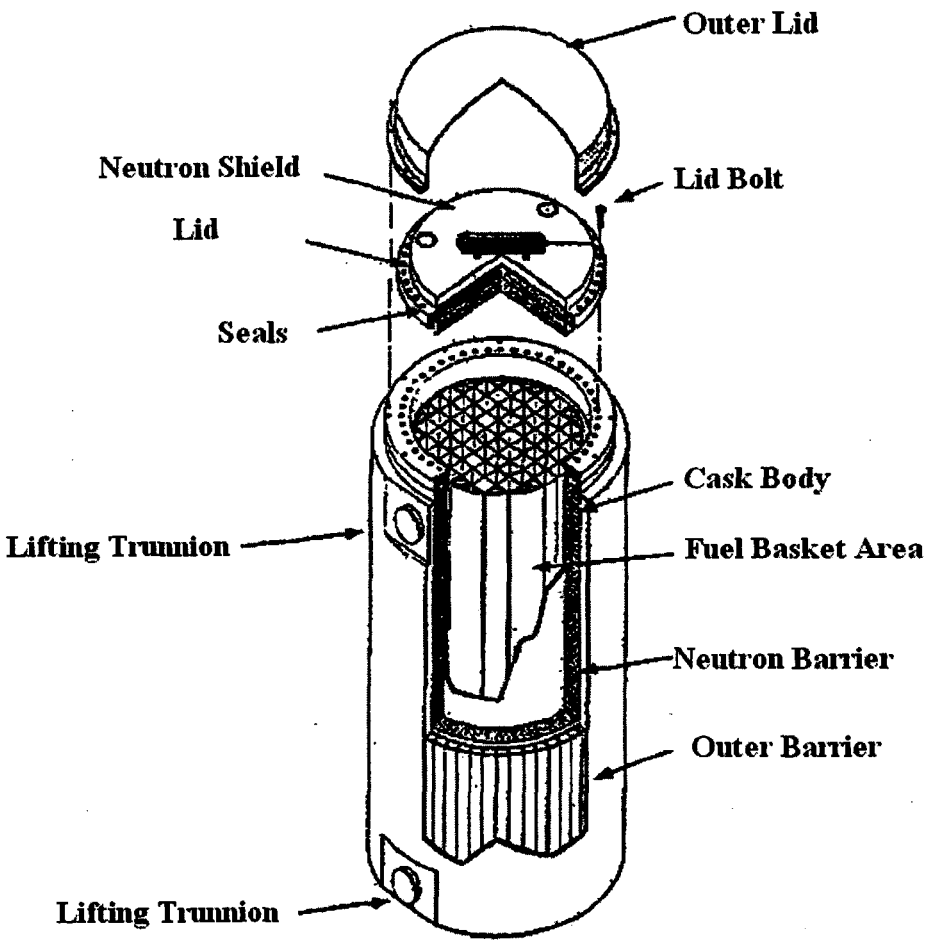

Figure 4-1. Metal Aging Cask Containing Bare Fuel

This figure is based on the *TN-68 Dry Storage Cask Final Safety Analysis Report* (Hunter 2002 [DIRS 170745]).

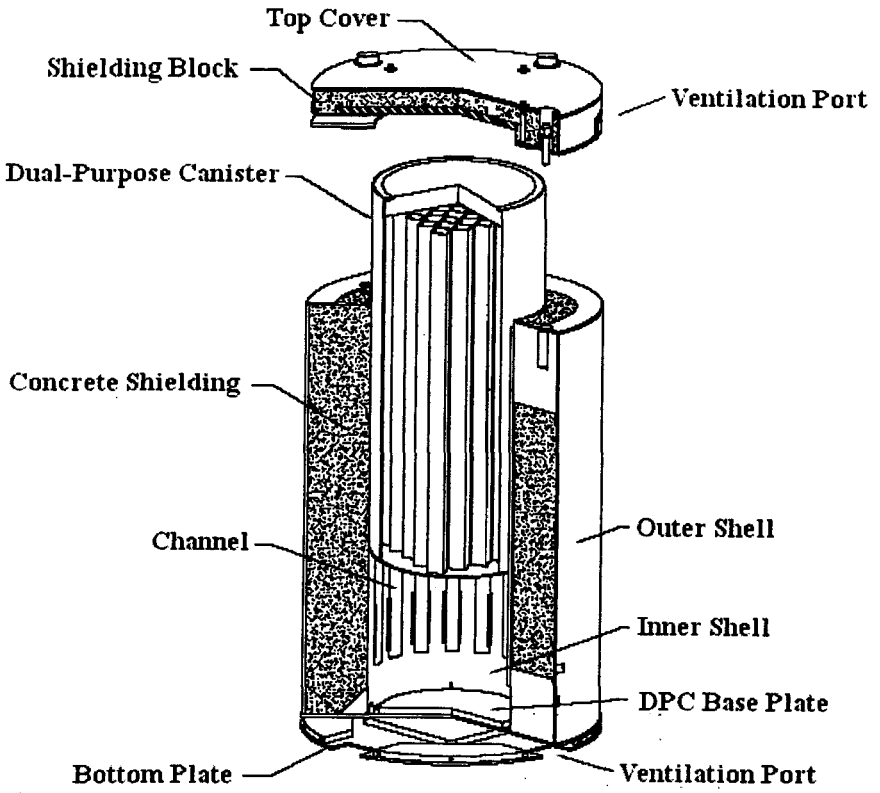

Figure 4-2. Concrete Aging Overpack with DPC

This figure is based on *Final Safety Analysis Report for the Holtec International Storage and Transfer Operation Reinforced Module Cask System, Hi-Storm 100 Cask System* (HOLTEC International 2002 [DIRS 168494])

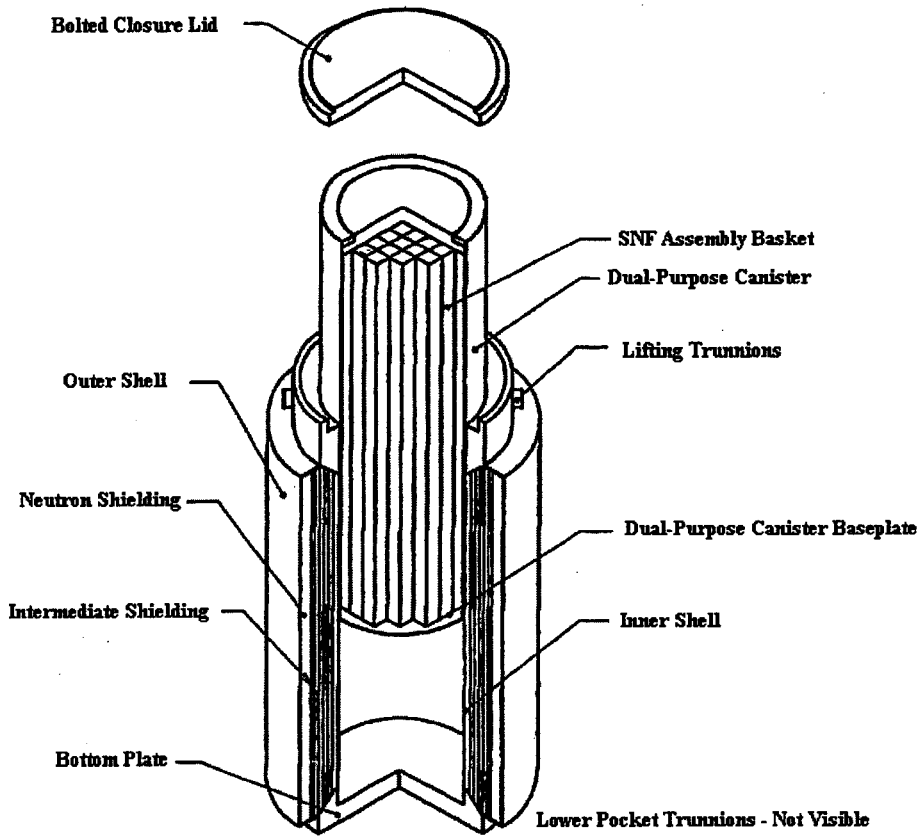

Figure 4-3. Metal Aging Overpack with DPC

This figure is derived from information in the *Final Safety Analysis Report for the Holtec International HI-STAR 100 Storage Cask System* (Gutherman 2003 [DIRS 169235])

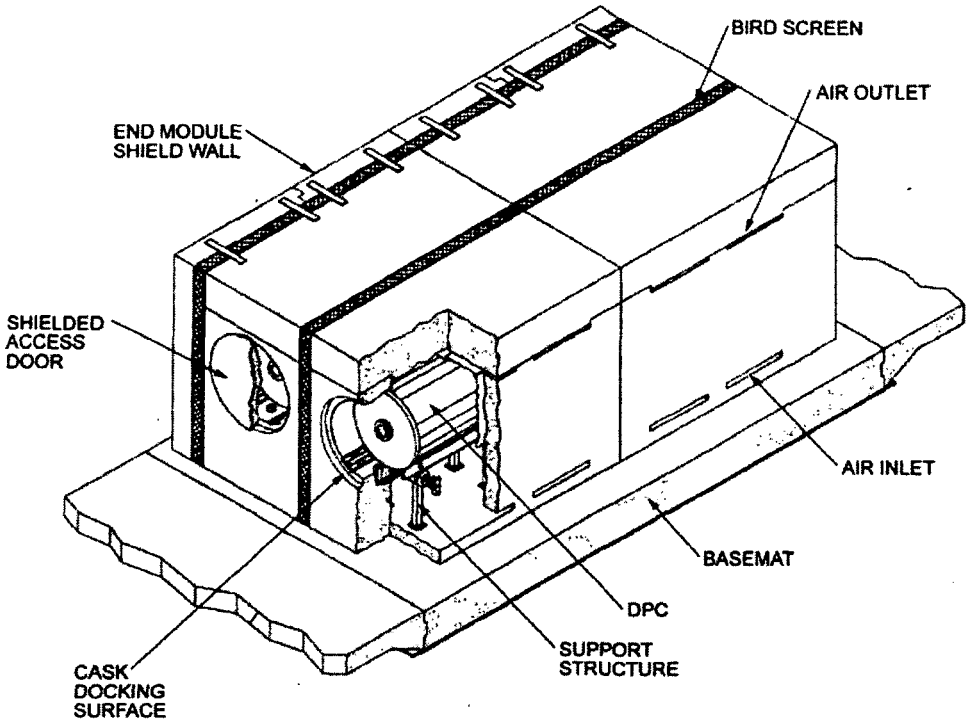

Figure 4-4. Horizontal Aging Module with DPC

This figure is derived from information in the final safety analysis report for the NUHOMS® horizontal storage system (Chopra 2002 [DIRS 162138]).

5. STANDARD AND NONSTANDARD SSCs

For the purpose of the "gap" analysis aging casks are characterized as standard SSCs or nonstandard SSCs. Standard SSCs are items that are currently in use at nuclear facilities, have a proven track record, and pose relatively low risk in their application for use at Yucca Mountain. Nonstandard SSCs are those items that are unique to the repository and have not been developed or placed into service previously at other locations. Usually nonstandard SSC have some precedent for their design and operation, but they have not been fully developed and integrated into a complete system. It is expected that there will only be minor modifications required to standard casks and overpack systems to bridge the gap between a nonstandard cask and the standard cask to meet the performance objectives for use at Yucca Mountain. Casks with extremely higher allowable burn-up and thermal loading than those currently identified are not part of this design development plan and will be addressed in the future.

This plan presents the aging cask gap analysis in Table 5-1, Aging Cask System Gap Analysis, for casks and overpack systems. The table summarizes the commercial availability of the major aging cask components and the forward looking design development strategy for site-specific metal casks and overpack systems. The information in Table 5-1 is primarily based on the report *Evaluation of 10 CFR 72 Licensed Casks for Use in Aging Spent Nuclear Fuel* (Buchheit 2004 [DIRS 172766]).

Table 5-1. Aging Cask and Overpack Gap Analysis

SSC (For a detailed description of each SSC see the Appendix A)	Standard SSC		References	Design Development Strategy
	Commercially Available	**Established Practices, Codes, or Standards**		
Commercially Available Cask and Overpack Systems				
Metal Cask (Figure 4-1)	Yes	Yes	(Buchheit 2004 [DIRS 172766], Table 1-2) and (Hunter 2002 [DIRS 170745])	Formally analyze the 10 CFR 72 [DIRS 173336] licensed component for Yucca Mountain specific conditions as summarized in Table 6-1
Concrete Overpack (Figure 4-2)	Yes	Yes	(Buchheit 2004 [DIRS 172766], Table 1-2) and (HOLTEC International 2002 [DIRS 168494])	
Metal Overpack (Figure 4-3)	Yes	Yes	(Buchheit 2004 [DIRS 172766], Table 1-2) and (Gutherman 2003 [DIRS 169235])	
Dual-Purpose Canisters (Figures 4-2, 4-3 and 4-4)	Yes	Yes	(Buchheit 2004 [DIRS 172766], Table 1-2), (HOLTEC International 2002 [DIRS 168494]), and (Gutherman 2003 [DIRS 169235])	
Basket Assembly for Metal Cask	Yes	Yes	No Reference	
Horizontal Aging Module (Figure 4-4)	Yes	Yes	(Buchheit 2004 [DIRS 172766], Table 1-2) and (Chopra 2002 [DIRS 162138])	
Site Specific Cask and Overpack Systems				
Metal cask for aging uncanistered CSNF that is loaded at Yucca Mountain repository	No	Yes	No Reference	Site-specific design to established practices, codes, standards, and NUREGs for Yucca Mountain specific conditions as summarized in Table 6-1.
Metal overpack with a canister for aging DOE SNF or high level waste.	No	Yes	No Reference	Site-specific design for overpack and basket assembly to established practices, codes, standards, and NUREGs for Yucca Mountain specific conditions as summarized in Table 6-1
Concrete overpack with a canister for aging DOE SNF or high level waste.	No	Yes	No Reference	

Components in Table 5-1 are part of the repository preclosure system and are considered ITS. They do not have postclosure functions and are not important to waste isolation at the geologic repository.

The primary structures, systems, and components (SSC) of the aging system are identified on the *Q-List* (BSC 2005 [DIRS 171190], Table A-1). The *Nuclear Safety Design Bases for License Application* (BSC 2005 [DIRS 171512]) identifies the nuclear safety requirements for SSCs that perform ITS functions. In all cases, ITS functions and requirements can be met using industry standard SSCs, and codes and standards developed specifically for nuclear applications. Therefore, at this time, no nonstandard SSCs associated with the existing aging casks or overpack systems have been identified. It is anticipated that the present procurement activities described in the scope of work document *Confirmation Report-Yucca Mountain CSNF Aging Casks* (BSC 2005 [DIRS 173420]) will confirm that established practices, codes, or standards are adequate to satisfy site-specific requirements. This procurement document requests consideration for the higher burn-up fuel of 60 GWD/MTHM, 4% initial enrichment for shielding calculations, and 5% initial enrichment for criticality calculations. Additionally the *Specification for the Procurement of Yucca Mountain Aging Casks* (TriVis 2005 [DIRS 173486]) lists these fuel characteristics for new metal casks.

The containment portion of the aging cask will be developed utilizing the standard codes from industry as noted in Table 5-2, Aging Cask Governing Codes. Specific exceptions to these codes, if needed, will be documented during the detailed design of the aging cask system.

Table 5-2. Aging Cask Governing Codes

Aging Cask (Shell and Head)	Applicable Codes	Editions/Years
General Requirements	ASME III, NCA	2004 Edition
Material Procurement	ASME III, NB-2000	2004 Edition
Design	ASME III, NB-3200	2004 Edition
Fabrication	ASME III, NB-4000	2004 Edition
Examination	ASME III, NB-5000	2004 Edition

This table is based on the Diablo Canyon Independent Spent Fuel Storage Installation (Womack 2001 [DIRS 172395], p. 4.0-1 and amended to use the current code edition). The table is subject to change and further review, but provides a starting point for design development.

As identified in Table 5-1 the non-standard casks and overpacks systems are:

1. A newly designed metal cask loaded at Yucca Mountain for aging uncanistered CSNF.
2. A newly designed metal aging overpack with a canister for aging DOE SNF or high level waste.
3. A newly designed concrete aging overpack with a canister for aging DOE SNF or high level waste.

The existing designs for standard cask and overpack systems identified in Table 5-1 will provide the basis for the new designs for the non-standard casks and overpack systems.

6. DESIGN DEVELOPMENT ACTIVITIES

6.1 Commercially Available Cask and Overpack Systems

Significant design development work has been completed for the Yucca Mountain Repository (YMR) aging system. In addition to the *SNF Aging System Description Document* (BSC 2005 [DIRS 172109]), other calculations and drawings are listed in Appendix D of this report. Current design documentation will be amended with additional details as the design proceeds. At this time four documents have been started or are completed that provide a preliminary technical basis for implementing existing systems at Yucca Mountain. They are:

- The preliminary evaluation report explained in Section 5, *Evaluation of 10 CFR 72 Licensed Casks for Use in Aging Spent Nuclear Fuel* (Buchheit 2004 [DIRS 172766]).
- The Yucca Mountain aging cask study *Aging Cask Study Submittal Item 1.1.1C, Letter Report - Evaluation on NRC Licensed Spent Fuel Storage Cask Systems with Respect to YMP Requirements* (Cogema 2004, [DIRS 173779]). This document is further discussed below.
- The Yucca Mountain aging cask performance specification, *Engineering Specification for the Procurement of Yucca Mountain Aging Casks* (TriVis 2005 [DIRS 173486]). This document is further discussed below.
- Confirmation from cask vendors that the casks in *Confirmation Report-Yucca Mountain CSNF Aging Casks* (BSC 2005 [DIRS 173420]). This document is further discussed below.

The comparative matrix is shown in *Aging Cask Study Submittal Item 1.1.1C, Letter Report - Evaluation on NRC Licensed Spent Fuel Storage Cask Systems with Respect to YMP Requirements* (Cogema 2004, [DIRS 173779]). This comparative matrix details the comparison of eight currently marketed metal casks and canister/overpack systems licensed under 10 CFR 72 and aging cask requirements as listed by the Aging SDD at that time. The summary of the study concluded that many of the requirements were met by all of the systems evaluated, but further study is needed to confirm certain requirements are bounded by the cask's Final Safety Analysis Report conditions.

The design and fabrication of metal casks and overpack systems will be based on a performance specification that ensures that the *Nuclear Safety Design Bases for License Application* (BSC 2005 [DIRS 171512]) requirements are satisfied. The site-specific performance requirements are provided in *Specification for the Procurement of Yucca Mountain Aging Casks* (TriVis 2005 [DIRS 173486]) for site-specific metal casks. Similar design performance specifications are planned for metal and concrete overpacks and the horizontal aging modules. The performance specification was developed using the same requirements as outlined in *Engineering Services, SNF Aging Casks/Site-Specific Casks* (BSC 2004 [DIRS 172746]).

A technical basis review will be performed to compare performance of existing casks licensed under 10 CFR 72 [DIRS 173336]) to Yucca Mountain site-specific requirements and conditions.

These site-specific conditions include hazards and operating conditions (i.e. 50 year life, temperatures, seismic, and aircraft hazards, etc.); and their ability to comply with the requirements of 10 CFR 63 [DIRS 173273]. The review will include engineering calculations and analyses of criticality, shielding, structural, containment (per the 10 CFR 63.2 definition), and thermal performance using Yucca Mountain design basis fuel types and site-specific conditions. The consequences of a dry fuel transfer, cask tip over, or slap down is also required. This review is currently underway and is further explained in *Confirmation Report-Yucca Mountain CSNF Aging Casks* (BSC 2005 [DIRS 173420]).

A fifth document is planned which is comparable to the *Specification for the Procurement of Yucca Mountain Aging Casks* (TriVis 2005 [DIRS 173486]), but is dedicated to the design of overpacks systems.

6.2 Summary of Calculations Pertinent to Aging Cask and Overpack Systems

The three previous documents (Buchheit 2004 [DIRS 172766]), (Cogema 2004 [DIRS 173779]), and (BSC 2005 [DIRS 173420]) document work that compares existing storage installations to the Yucca Mountain Repository requirements. Another document (TriVis 2005 [DIRS 173486]) specifies the present Yucca Mountain requirements for a future subcontractor to design casks or overpack system. In addition to these four documents various preliminary calculations have already been completed by BSC (as listed in Table D-1) for criticality safety, worker dose, dose rates, and shielding. As the aging cask design matures and systems are evaluated for implementation at Yucca Mountain additional calculations will be performed. Table 6-1, Aging Cask Design Calculation Summary, provides a summary of the design calculations and responsible organization that are planned to support aging cask design development. These calculations will demonstrate satisfaction of the Nuclear Safety Design Basis criteria (see Table 8-1) for the casks and overpack/canisters.

Table 6-1. Aging Cask Design Calculation Summary

Calculation	Description	Entity Performing Calculation
Structural	Examines seismic loads, tornado loads, drops, and other scenarios that could potentially affect the structural integrity of the aging cask.	Cask Vendor
Thermal	Examines the thermal aspects of the cask system to ensure that CSNF will remain within specified temperature limits.	Cask Vendor
Closure and Sealing	Reviews the process to close and seal the aging cask, materials to be used, and bolting configuration.	Cask Vendor
Safety and Performance	Reviews the critical aspects that affect safety and performance. These analyses are discussed in further detail in subsequent sections.	Cask Vendor and BSC
Shielding	Evaluates the shielding characteristics of the system. Calculation will be follow-on work that has started and is documented in *Shielding Evaluation for Spent Nuclear Fuel Aging Areas* (BSC 2004 [DIRS 169308]).	Cask Vendor and BSC
Criticality	Ensures that the design is criticality safe and follows work started that is documented in *Aging Facility Criticality Safety Calculations* (BSC 2004 [DIRS 171589]).	Cask Vendor and BSC

Calculation	Description	Entity Performing Calculation
Dose Assessment	Calculation to ensure that worker radiological doses are ALARA. Calculation is follow-on work to present data currently documented in *Aging Facility Worker Dose Assessment* (BSC 2005 [DIRS 173167]).	Cask Vendor and BSC
Fire Hazard	Aging casks are discussed in *Site Fire Hazard Analysis* (BSC 2005 [DIRS 172174], Section 6.3.2). Additional analysis will confirm that the NSDB (see Table 8-1) are satisfied when the aging cask design is further advanced.	Cask Vendor and BSC

6.3 Site-Specific Cask and Overpack Systems

A procurement package will be created for the site-specific cask and overpack system design. The successful qualified contractor for this design will perform the calculations described in Section 6.2. Design for a site-specific cask for uncanistered CSNF and the metal and concrete overpacks for DOE SNF and HLW will utilize existing technology described for commercially available casks and overpacks.

6.4 Benchmarking and Prototype Testing

Benchmarking is accomplished by comparing analytical results and physical characteristics of new designs to those of commercially licensed storage system. The comparison considers differences in design basis, performance requirements, environmental hazards, and external hazards.

An additional design development activity, prototype testing, has been identified that may be required to ensure compliance with the requirements and evaluations listed in this section and in Section 7 and 8. Prototype testing may be required when the operational performance reports for the current 10 CFR 72 systems or the newly designed cask and overpack systems are completed and evaluated. For example, testing, may be required to demonstrate that the 8 minute fire and temperature limit of 800° C, as specified for Yucca Mountain (BSC 2005 [DIRS 173420], Table 4-2). Seismic analyses may also indicate that prototype testing of aging casks and overpack systems is needed. The need for testing will be developed after the technical performance evaluations are completed. Table B-1 presents a preliminary list of tests that may be performed to satisfy the NSDB requirements.

The schedule logic of completing the operational performance and the environmental and external event calculations and reports is presented in Section 9.0 of this report where the logic ties for future activities are presented. Definitive requirements for prototype testing will be identified after the evaluation of the systems are completed.

7. OPERATIONAL REQUIREMENTS AND DATA NEEDS

An objective of this design development plan is to demonstrate the functionality of the aging cask and overpack systems ITS functions under representative operational conditions at Yucca Mountain. The design activities listed in Table 6-1 apply to the casks and overpack systems and their design at nuclear utilities and at Yucca Mountain. The work being conducted per

Confirmation Report-Yucca Mountain CSNF Aging Casks (BSC 2005 [DIRS 173420]) will identify additional design requirements in the existing design which can be translated to any new design. The additional requirements presently identified are canister and overpack systems lift heights and the impacts from fuel with higher burn-up rates.

7.1 Cask and Overpack System Lift Heights

Drop heights and handling procedures at Yucca Mountain are the primary unique site-specific issues that have not been conducted and need to be addressed for the currently licensed storage casks. A separate specification is being prepared to address drop heights for existing DPCs. Canisterized CSNF and aging casks containing bare CSNF at nuclear utilities have a variety of lift height specifications that are utilized during handling operations. Most handling at nuclear utilities is performed in pools and significant drops onto a dry surface are not possible. The technology for analyzing impacts to the canister and overpack when they have been dropped is proven and each existing cask vendor has the methodology to theoretically ensure there is no damage to the canister or overpack. Upon review of the theoretical analysis additional prototype testing may be required.

7.2 Fuel with Higher Enrichment, Burn-up, and Thermal Loading

Technology also exists that provides insight to the results on the canister and over pack when exposed to higher burn-up fuels. Testing can also be performed to verify the results of the theoretical analysis. The site-specific aging cask will be designed to accommodate fuel 60 GWD/MTHM, 4% initial enrichment for shielding calculations, and 5% initial enrichment for criticality calculations with a heat output of 1,185 watts per pressurized water reactor assembly or 435 watts per boiling water reactor assembly.

The drop height analyses and impacts to higher burn-up fuel are included in site specific requirements specified in *Confirmation Report-Yucca Mountain CSNF Aging Casks* (BSC 2005 [DIRS 173420]). The higher enrichment, burn-up values, and drop heights are included in *Specification for the Procurement of Yucca Mountain Aging Casks* (TriVis 2005 [DIRS 173486]).

8. EXPECTED RESULTS AND SUCCESS CRITERIA

The following section outlines the expected results and success criteria based on satisfying the ITS performance requirements specified within the NSDB (BSC 2005 [DIRS 171512]). Deviations reported to these expectations should be subject to close inspection or further evaluation. If necessary, prototype testing may be required to verify calculation results. The *Nuclear Safety Design Bases for License Application* contains nuclear safety requirements for a site-specific cask and overpack system. These requirements include nuclear safety requirements for horizontal aging modules, safety functions that ITS systems must perform, and drop height requirements for casks, canisters, containers, and waste packages (BSC 2005 [DIRS 171512], p. A-54, p. A-53, Appendix B, and Appendix C respectively).

8.1 Nuclear Safety Testing

The confirmation of requirement satisfaction will occur by evaluating properties of individual casks and overpack systems compared to Category 2 event sequences to ensure radiation exposure levels shall not be exceeded. Table 8-1 is a summary of the primary NSDB requirements that have been established. Satisfaction of the NSDB requirements will be accomplished by implementation of planning, testing, analysis, verification, reviewing, demonstration, inspection, and other methods that will be accomplished in accordance with *Quality Assurance Requirements and Description* (DOE 2004 [DIRS 171539]).

Table 8-1. Nuclear Safety Design Basis Requirements

Number	NSDB Performance Requirement	*Verification Method*
Site-Specific Vertical Cask (1-15)		
1	The aging cask shall be designed for loading conditions associated with a DBGM-2 seismic event. In addition, an analysis shall demonstrate that the aging cask system has sufficient seismic design margin to ensure that "no tip over" and "no breach" safety functions are maintained for loading conditions associated with a BDBGM seismic event (BSC 2005 [DIRS 171512], p. A-53).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks.
2	Tip over of aging casks as a result of extreme wind or tornado events shall be precluded (BSC 2005 [DIRS 171512], p. A-53).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks.
3	The design of aging casks shall ensure that they can withstand the differential pressure associated with a passing tornado without loss of function (BSC 2005 [DIRS 171512], p. A-53).	This task will be performed with calculations benchmarking existing calculations performed for previously licensed casks.
4	Tip over of aging casks as a result of being struck by a design basis tornado missile shall be precluded (BSC 2005 [DIRS 171512], p. A-53).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks.
5	The design of aging casks shall ensure that they can withstand being struck by a design basis tornado missile without loss of function (BSC 2005 [DIRS 171512], p. A-53).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks.
6	The design of the aging casks shall ensure that they can withstand a drop from the maximum handling height of an aging cask transporter without loss of function (BSC 2005 [DIRS 171512], p. A-53).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks.
7	The design of the aging casks shall ensure acceptable thermal design performance during extreme temperature events (BSC 2005 [DIRS 171512], p. A-53).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks.
8	Short-duration vent blockage events involving aging casks shall be precluded (BSC 2005 [DIRS 171512], p. A-53).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks to determine the limitations. Operational procedures will be instituted to ensure the calculated limits are not exceeded.
9	The aging casks shall not lose their intended function under conditions involving the maximum snow, sand, or ash loads (BSC 2005 [DIRS 171512], p. A-53).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks

10	The design of the aging casks shall ensure that welded closure confinement system design precludes loss of confinement following closure of the casks to meet life cycle operations (BSC 2005 [DIRS 171512], p. A-53).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks
11	The design of the aging cask shall ensure that the bolted closure cask design protects seals from damage following closure to maintain its primary confinement boundary function to meet life cycle operations (BSC 2005 [DIRS 171512], p. A-53).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks. The operational procedures will ensure monitoring of the internal pressures so the calculated limits are maintained.
12	Aging casks shall be designed to ensure nuclear criticality safety with optimum moderation and the most reactive waste forms. Criticality safety will be maintained despite any geometric rearrangements due to a drop or other handling incident (BSC 2005 [DIRS 171512], p. A-54).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks
13	In the event of a credible fire, the wall temperature of a loaded aging cask, being handled or at rest, shall not exceed its allowable operating range (BSC 2005 [DIRS 171512], p. A-54).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks
14	In the event of a credible fire, the wall temperature of a loaded aging cask with docking ring installed shall not exceed its allowable operating range (BSC 2005 [DIRS 171512], p. A-54).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks. (This will include dry versus wet fuel transfer)
15	An aging cask shall not breach as a result of the credible fire (BSC 2005 [DIRS 171512], p. A-54).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks
Horizontal Aging Module (16-24)		
16	Horizontal aging modules shall be designed for loading conditions associated with a DBGM-2 seismic event. In addition, an analysis shall demonstrate that the HAMs have sufficient seismic design margin to ensure that a "no collapse" safety function is maintained for loading conditions associated with a BDBGM seismic event (BSC 2005 [DIRS 171512], p. A-54).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks
17	Tip-over of modules as a result of extreme wind or tornado events shall be precluded (BSC 2005 [DIRS 171512], p. A-54).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks
18	The design of modules shall ensure that they can withstand the differential pressure associated with a passing tornado without loss of function (BSC 2005 [DIRS 171512], p. A-54).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks
19	Tip-over of modules as a result of being struck by a design basis tornado missile shall be precluded (BSC 2005 [DIRS 171512], p. A-54).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks
20	The design of aging modules shall ensure that they can withstand being struck by a design basis tornado missile without loss of function (BSC 2005 [DIRS 171512], p. A-54).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks
21	The design of the modules shall ensure acceptable thermal design performance during extreme temperature events (BSC 2005 [DIRS 171512], p. A-54).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks
22	Short-duration vent blockage events involving modules	This will be verified with calculations

	shall be precluded (BSC 2005 [DIRS 171512], p. A-55)	benchmarking existing calculations performed for previously licensed casks
23	The modules shall not lose their intended function under conditions involving the maximum snow, sand, or ash loads.(BSC 2005 [DIRS 171512], p. A-55)	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks. Operational procedures will be created to ensure boundaries established by the calculations are maintained.
24	The design of the modules shall ensure that welded closure casks/canister confinement system designs preclude loss of confinement following closure of the casks to meet life cycle operations (BSC 2005 [DIRS 171512], p. A-55).	This will be verified with calculations benchmarking existing calculations performed for previously licensed casks.

9. LOGIC TIES FOR FUTURE ACTIVITIES

Activities for the aging casks and overpack system have been established to guide implementation of the program. The activities and schedule are presented in Appendix C. Logic ties to the Design Engineering, Procurement, and Construction organizations are identified in Table C-1. The ties correspond to the major design development milestones of the YMR aging cask system.

10. CONCLUSIONS

This plan identifies a means to confirm there are no significant technical gaps between current dry storage systems and the proposed aging system at Yucca Mountain. After completion of the operational performance report and the external event report being prepared per *Confirmation Report-Yucca Mountain CSNF Aging Casks* (BSC 2005 [DIRS 173420]) specific modification will be highlighted.

This plan also identifies the means to demonstrate that current technologies used to license the existing aging casks and overpacks systems can be used to design new aging casks and overpacks systems in accordance to 10 CFR 63 [DIRS 173273]. This plan discusses that no significant technical gaps between current dry storage systems and the proposed new casks and overpacks are apparent. An evaluation of drop heights and handling conditions at Yucca Mountain will be needed since the repository design for handling waste varies from what is currently practiced at nuclear utilities. The logic for future activities presented in Section 9.0 represents a path forward for successful implementation of aging casks.

Design development of aging asks is primarily identified in *Confirmation Report-Yucca Mountain CSNF Aging Casks* (BSC 2005 [DIRS 173420]) and *Engineering Services, SNF Aging Casks/Site-Specific Casks* [BSC 2004 [DIRS 172746]). These activities, in addition to the work performed in *Evaluation of 10 CFR 72 Licensed Casks for Use in Aging Spent Nuclear Fuel* (Buchheit 2004 [DIRS 172766]), provide a firm basis for proceeding with the logic outlined in Section 9.0 and Appendix C.

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Appendix A. Glossary

Aging Cask

A generic term for a component or combination of components that confine commercial SNF and provide a heat transfer path, criticality control, radioactive shielding, and environmental protection under normal, off-normal, and accident conditions of aging. This includes:

- A cask, with integral shielding and an internal basket assembly, containing uncanistered commercial SNF.
- A commercial dual-purpose canister in a metal or concrete overpack.
- A DPC in a horizontal aging module

Aging casks are currently manufactured by a number of vendors. They are not unique to Yucca Mountain.

Bare Fuel

Spent nuclear fuel that has not been encased into a confinement vessel such as a canister.

Basket Assembly

The internal support and fuel assembly positioning structure placed within a cask or canister cavity that provides a heat transfer path and criticality control under normal, off-normal, and accident conditions of storage, transportation, and/or aging.

Canister

A relatively thin walled metal vessel, with an internal basket assembly, designed to confine SNF assemblies and provide a heat transfer path and criticality control under normal, off-normal, and accident conditions. Canisters for this DDP include dual-purpose canisters loaded at the utilities and the DOE spent nuclear fuel canister and the DOE high level waste canister loaded at the DOE facilities.

Cask

A relatively thick walled metal vessel, with an internal basket assembly, designed to confine SNF assemblies and provide a heat transfer path and criticality control under normal, off-normal, and accident conditions.

Crawler

A track type transporter designed to move an aging cask, or a combination of YMR aging canister and overpack, to/from the waste handling facilities and the aging pads.

Dual-Purpose Canister

A canister, loaded with CSNF at a commercial utility, that is used for both storage and transportation of spent nuclear fuel. Currently, dual-purpose canisters are not certified for underground emplacement.

Gap Analysis	An evaluation of designs that include requirements, codes, and standards to identify the missing elements that are not currently used in nuclear facilities. An analysis of the informational or data "gaps" in a proposed design when compared to existing designs.
Overpack	A concrete or metal, vertically oriented, right circular cylinder that provides structural protection, radiological shielding, and environmental protection to an internal canister. At Yucca Mountain an overpack will be designed to function in tandem with a YMR aging canister.
Overpack System	A designed system which includes the overpacks and the canister
Nonstandard SSC	Items that have been identified through a gap analysis that have requirements placed on them or design features that have not been applied to current components in the nuclear industry.
Standard SSC	Items currently in use at nuclear facilities that have been developed to existing codes and standards.

Appendix B. Prototype Testing and Data Acquisition Plan

Prototype testing may be performed to assure that various SSCs associated with the aging cask system will perform their intended safety function. Table B-1 is a brief summary of the ITS items that may be tested and the NSDB requirement (BSC 2005 [DIRS 171512]) that the test is intended to address.

Table B-1. ITS SSC Prototype Testing and Data Acquisition Plan

Nuclear Safety Requirement From Table 8-1	**Item**	**Test**
1, 2, 4, 5, 6, 9, 12	Metal Cask Structure	Drop, Impact, Slapdown
3, 10, and 11	Metal Cask Seals	Pressure and Confinement
13, 14, and 15	Metal Cask Structure	Fire Exposure
7 and 8	Metal Cask Structure	Thermal Performance
1, 2, 4, 5, 6, 9, 12	Concrete Overpack	Drop, Impact, Slapdown
13, 14, and 15	Concrete Overpack	Fire Exposure
7 and 8	Concrete Overpack	Thermal Performance
1, 2, 4, 5, 6, 9, 12	Metal Overpack	Drop, Impact, Slapdown
13, 14, and 15	Metal Overpack	Fire Exposure
7	Metal Overpack	Thermal Performance
16, 17, 18, 19, 20, and 23	Horizontal Aging Module	Structural Performance
21 and 22	Horizontal Aging Module	Thermal Performance
24	Horizontal Aging Module	Confinement

Metal cask is an aging cask containing bare fuel.
Concrete overpack contains a DPC.
Metal overpack contains a DPC.
Horizontal aging module is a concrete, vault-type structure for aging horizontal DPCs.

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Appendix C. Design Logic Ties

Table C-1. Aging Cask Design Development Milestones

Design Development Milestone	Description	P3 Logic ID	P3 Logic Description	Target Completion Date
Commercially Available Cask and Overpack Systems				
Evaluate existing cask systems	An evaluation of the dry CSNF storage systems licensed per 10 CFR 72 to determine their suitability for use in the SNF aging system at Yucca Mountain (Buchheit 2005, [DIRS 172766])	Completed activity		Completed
Prepare and issue scope of work to direct 10 CFR 72 license holders to evaluate existing casks and overpacks systems to site-specific requirements	Request from existing cask and overpack system manufacturers to determine how existing casks respond to site-specific requirements	RPTAP005	Develop ONT Cask Scope of Work	Completed
		RPTAP011	Issue Cask Scope of Work to ONT	Completed
Prepare and issue scope of work to direct 10 CFR 72 license holders to evaluate drop height impacts on existing DPCs	Request from existing vendors acceptable drop height boundaries	TBD	TBD	TBD
Receive from cask vendors a letter stating how existing casks and overpacks systems respond to site-specific requirements	Cask vendors to provide insight as to how existing casks and overpacks systems respond to site specific requirements	RPTAP014	Non-Cogema Vendor Prep. ONT Cask Conf. Letter	06/20/05
Evaluate Vendor Confirmation Letters	Evaluate data (confirmation letters) from cask vendors that provided insight as to how existing casks and overpacks systems respond to site specific requirements.	RPTAP016	Evaluate ONT Cask Confirmation Letter	03/17/05

Design Development Milestone	Description	P3 Logic ID	P3 Logic Description	Target Completion Date
Revise existing scope of work for more detail on how existing casks and overpacks systems respond to site-specific requirements	Continue the evaluation by existing cask and overpack system suppliers to confirm acceptability or adaptability to satisfy site-specific requirements	RPTAP021	ONT Revises Vendor Scope of Work	6/20/05(EST)
		RPTAP0412	ONT Vendor Criticality Calc. Aging Cask	10/15/05(EST)
		RPTAP0413	ONT Vendor Structural Calc. Aging Cask	10/15/05(EST)
		RPTAP0414	ONT Vendor Shielding Calc. Aging Cask	10/15/05(EST)
Confirm technical basis	Perform technical audit of vendor supplied calculations	TBD	TBD	11/15/05(EST)
Update SAR section	Revise SAR as required to incorporate results of calculations.	RPTAP0314	Provide SAR 1.2.7 (2nd Update –Site spec. Canister)	05/10/06 (EST)
Cask and Overpack System				
Develop site specific performance specifications (in process)	Develop a specification that establishes the design requirements for a site-specific system at Yucca Mountain. This specification is to be included in a procurement package for the design, fabrication and delivery of a cask or overpack system	RPSK095	Subcontractor Develop Cask Procurement Spec	06/20/05
Select design subcontractor for aging casks	Perform the bid, bid evaluation, and award for contractor to design a site-specific cask or overpack system.	RPSK100	Bid/Evaluate /Award	06/15/06

Design Development Milestone	Description	P3 Logic ID	P3 Logic Description	Target Completion Date
Prepare preliminary design of site-specific casks and overpacks systems	The design subcontractor is to provide a preliminary (30%) design of casks and overpack systems	RPSKA143	Subcontractor Develop Cask Design-LA	01/04/07
Complete analyses of aging systems as listed in Table 6-1	The design subcontractor is to complete the design calculations needed ensure that the casks will perform as intended	RPSKA142	Subcontractor Develop Final Cask Design	06/15/07
Perform any prototype testing if required (Appendix B)	Determine and complete any prototyping testing	RPSKA142	Subcontractor Develop Final Cask Design	06/15/07
Obtain license approval for casks and overpack systems	With the completed design from the design subcontractor, complete the NRC licensing process for cask and overpack system.	RPSK0135	Cask Vendor Design –LA Part 63 (license Process)	01/05/08
Cask and Overpack System Procurement				
Issue contracts to purchase casks and overpack systems	Issue all contract documents to procure aging cask SSCs	RPSK0245	Fabricate & Deliver Aging Cask	01/15/08
Determine the cask fabrication subcontractor.	Perform the bid, bid evaluation, and award for contractor to fabricate a site-specific cask or overpack system.	RPSK0245	Fabricate & Deliver Aging Cask	01/15/08
Fabricate casks	Successful subcontractors to manufacture appropriate aging cask SSCs off site. Some components such as the concrete overpacks may be fabricated at the repository.	RPSK0245	Fabricate & Deliver Aging Cask	01/15/08
Receipt of aging casks to Yucca Mountain	Receive casks at the repository, inspect, verify acceptability	RPSK0245	Fabricate & Deliver Aging Cask	12/01/11
Conduct start-up activities/testing as required	Perform start-up activities for aging cask system activities	TBD	TBD	TBD

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Appendix D. Current Aging System Design

Tables D-1 and D-2 summarizes the work accomplished by listing currently controlled aging system calculations and drawings.

Table D-1. Summary of Controlled Aging System Calculations

Document Title	Document Identifier	Effective Date
Aging Facility Criticality Safety Calculations	170-00C-HA00-00100-000-00B	September 10, 2004
Aging Facility Worker Dose Assessment	170-00C-HA00-00200-000-00A	March 24, 2005
Design of a Concrete Slab for Storage of SNF and HLW casks	170-00C-HAP0-00100-000-00B	February 14, 2005
Shielding Evaluations for Spent Nuclear Fuel Aging Areas	170-00C-HAP0-00200-000-00A	May 10, 2004
Dose Rate Evaluations for Spent Nuclear Fuel Aging Areas	170-00C-HAP0-00400-000-00A	December 16, 2004
Midway Valley Aging Site Layout Drawing Support Calculation	170-C0C-C000-00100-000-00A	March 26, 2004

Table D-2. Summary of Cask-Related Controlled Aging System Drawings

Aging System Drawing Title	Document Identifier	Approval Date
Geologic Repository Operations Area Aging Site Plan	170-C00-MGR0-00101-000-00A	March 26, 2004
Spent Nuclear Fuel Aging Area 1000 MTHM Aging Module Concrete Plan and Sections	170-DB0-HAP0-00101-000-00A	May 7, 2004
SNF Aging System Instrument Systems Functional Block Diagram	170-J00-HA00-00101-000-00A	April 26, 2004
SNF Aging System Block Flow Diagram Level 2	170-MH0-HA00-00101-000-00A	April 23, 2004
SNF Aging System Block Flow Diagram Level 3 (Sheet 1 of 2)	170-MH0-HA00-00201-000-00A	April 23, 2004
SNF Aging System Block Flow Diagram Level 3 (Sheet 2)	170-MH0-HA00-00202-000-00A	April 22, 2004
SNF Aging System Mechanical Flow Diagram (Sheet 1 of 3)	170-MH0-HA00-00301-000-00A	April 22, 2004
SNF Aging System Mechanical Flow Diagram (Sheet 2)	170-MH0-HA00-00302-000-00A	April 22, 2004
SNF Aging System Mechanical Flow Diagram (Sheet 3)	170-MH0-HA00-00303-000-00A	April 22, 2004

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Appendix E. Design Development Plan Acceptance and Completion Criteria

The following table, Table E-1, Aging Cask DDP Acceptance and Completion Criteria, presents the acceptance and completion criteria that were established for this plan. The table presents a description of the criteria and the location within this plan where satisfaction of the criteria is demonstrated.

Table E-1. Aging Cask DDP Acceptance and Completion Criteria

	Criteria from Deliverable Definition Sheet	Satisfaction Description
1.	Plan shall be prepared, checked, approved, and distributed in accordance with procedure LP-ENG-014-BSC, *Engineering Studies,* (LP-ENG-014-BSC [DIRS 168862])	Plan was prepared in accordance with stated procedure. See Section 3.0.
2.	Plan shall be consistent with requirements and guidance established within 10 CFR 63 (10 CFR 63 [DIRS 173273]) and NUREG-1804 (NRC 2003 [DIRS 163274])	Plan scope is consistent with stated documents, see Section 2.0.
3.	Plan and associated gap analysis shall identify ITS and important to waste isolation safety functions that are expected to be met by non-standard SSCs.	Plan has identified that no nonstandard SSC are associated with the aging cask system. See Section 5.0.
4.	Plan shall identify the necessary design development requirements, including calculations, analyses, and testing, to demonstrate that the safety functions can be achieved as required	Analysis and testing activities are presented in Section 6.0 and Section 8.0.
5.	Plan shall provide a description of each test or development activities.	Activities are described in Section 6.
6.	Plan shall describe information/data collection and inspection requirements.	Plan presents information and data requirements in Section 7.0.
7.	Plan shall describe expected results and success criteria that will be used for performance acceptance.	Expected results and success criteria are in Section 8.0.
8.	Plan shall identify logic ties to the engineering, procurement, and construction for availability of information and inspections and performance acceptance activities.	Logic ties are explained in Section 9.0 and Table C-1.

Note: Based on letter Arthur to Mitchell, June 2, 2005, BSC Correspondence Log # 0602055754.

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